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AUTHOR HAVEMAN, JACQUELINE E.; FARLEY, FRANK H.
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ABSTRACT

IN THREE EXPERIMENTS EMPLOYING 60 SS, AROUSAL WAS MANIPULATED BY WHITE NOISE DURING PAIRED-ASSOCIATE, SERIAL, AND FREE LEARNING IN AN EFFORT TO INVESTIGATE THE RELATIONSHIPS OF AROUSAL AND LONG-TERM RECALL. PREVIOUS RESEARCH SUGGESTED THAT HIGH AROUSAL IN THE PAIRED-ASSOCIATE PARADIGM LEADS TO BETTER RETENTION RELATIVE TO LOW AROUSAL. THE PRESENT RESEARCH CONFIRMED THIS FINDING ONLY IN THE FREE LEARNING SITUATION. THE RESULTS SUGGESTED THAT THE EFFECTS OF AROUSAL ARE DEPENDENT ON THE NATURE OF THE MATERIAL TO BE PROCESSED AND THE INTENSITY OF AROUSAL. CERTAIN PROBLEMS OF RESEARCH DESIGN IN THIS AREA WERE DISCUSSED. (AUTHOR)

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AROUSAL AND RETENTION IN PAIRED-ASSOCIATE, SERIAL, AND FREE LEARNING

WISCONSIN RESEARCH AND DEVELOPMENT

CENTER FOR
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Technical Report No. 91

AROUSAL AND RETENTION IN PAIRED-ASSOCIATE, SERIAL, AND FREE LEARNING

By Jacqueline E. Haveman and Frank H. Farley

Report from the Project on Motivation and Individual Differences in Learning and Retention

Frank H. Farley, Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
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The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Motivation and Individual Differences in Learning and Retention Project from Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Learning and Memory Project has the long-term goal of developing a theory of individual differences and motivation. The intermediate objective is to generate new knowledge of the learning and memory processes, particularly their developmental relationship to individual differences and to motivation.

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ABSTRACT

In three experiments employing 60 Ss, arousal was manipulated by white noise during paired-associate, serial, and free learning in an effort to investigate the relationships of arousal and long-term recall. Previous research suggested that high arousal in the paired-associate paradigm leads to better retention relative to low arousal. The present research confirmed this finding only in the free learning situation. The results suggested that the effects of arousal are dependent on the nature of the material to be processed and the intensity of arousal. Certain problems of research design in this area were discussed.

I

INTRODUCTION AND REVIEW OF THE LITERATURE

One of the more complex issues in the experimental literature on verbal learning concerns the effects of motivation on acquisition and retention. Until the 1960's the majority of experimental investigations of verbal learning manipulated the classical associative factors such as degree of learning, frequency of stimulus presentation, meaningfulness of items, and similarity of material (Weiner, 1966). Yet, according to Weiner, it seems intuitively reasonable that variations in motivation might also affect learning and recall. However, Kausler's (1966) recent collection and review of the contemporary theory and research in verbal learning mentioned only that "motivational theorists have also found verbal learning to be a fruitful milieu for tests of their hypothesis [p. 3]." Slamecka (1967) in a collection of papers on human learning and memory likewise gives no space to motivational variables. Two important symposia (Cofer, 1961; Cofer & Musgrave, 1963) on verbal learning and behavior did not include papers on motivational factors. Weiner (1966) suggests that the nonassociative factors which include motivation should not be limited to the concept of drive but should include the temporary arousal states or activation levels (Duffy, 1962) of the individual.

The fact that Kausler (1966) and the other writers cited above include no experiments dealing with nonassociative factors in verbal learning should not be taken to indicate that no work has been done in this area. Research by Obrist (1950) and Thompson and Obrist (1964) has been concerned with relating the subject's (S's) arousal level associated with individual items to the efficiency of learning a list. These authors measured galvanic skin response (GSR) and electroencephalographic (EEG) changes during serial learning (SL) of nonsense syllables. It was shown that while Ss were engaged in learning, mean GSR magnitude was higher than during control periods. The two indices (GSR and EEG) showed a tendency for each syllable to produce the highest arousal at about the time it was beginning to be correctly anticipated. Obrist (1962) in another SL experiment found correct anticipation on different days to be linearly related to heart-rate and electrodermographic measures of autonomic activity in two subjects and curvilinearly related in three subjects. Berry (1962) measured skin conductance during exposure to paired associates (PA's) with instructions to learn, and found that recall was highest in Ss with intermediate conductance levels. On the other hand, Kleinsmith, Kaplan, and Tarte (1963) employing PA material found that at 6 minutes recall scores of Ss with intermediate levels were the highest, but when the interval was increased to one week recall scores increased monotonically with skin conductance.

A further series of experiments on the relationship between arousal and verbal learning has been carried out at the University of Michigan. This work has stemmed largely from the "action decrement" theory of Walker (1958), particularly in its modified form as summarized by Walker and Tarte (1963).

> (1) The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets up an active, perseverative trace process which persists for a considerable period of time. (2) The perseverative process has two important dynamic characteristics: (a) permanent memory is laid down during this active phase in a gradual fashion; (b) during the active period, there is a degree of temporary inhibition of recall, i.e., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption). (3) High arousal during the associative process will result in a more intensely active trace process. The more intense activity will result in

greater ultimate memory but greater temporary inhibition against recall [p. 113].

Some confirmation of this position has been reported by Kleinsmith and Kaplan (1963) employing a PA task with eight single words as stimulus items and eight single digits as response items. The stimulus items were KISS, RAPE, VOMIT, EXAM, DANCE, MONEY, LOVE and were a priori judged by the experimenters (Es) to be differentially arousing. A single learning trial was followed by a single recall trial. The interval between learning and recall was varied from 2 minutes to 1 week. In order to determine empirically the arousal effects of each stimulus word, skin resistance was recorded during learning. It was found that associations learned in the presence of low arousal as indicated by little change in skin resistance showed high immediate recall but poor delayed recall (45 minutes and 1 week) relative to items associated under high arousal as indicated by a large skin resistance change. The latter items demonstrated poor immediate recall but high recall on retention tests 45 minutes and 1 week later. This same type of result, i.e., poor immediate recall but higher later recall of items learned under high arousal was later obtained by Kleinsmith and Kaplan (1964) using six low-association nonsense syllables as stimuli and six single digits as responses.

Walker and Tarte (1963) have replicated the Kleinsmith and Kaplan studies using homogeneous and mixed lists of high- and low-arousal words. High-arousal words were MONEY, RAPE, SLUT, EMBRACE, KISS, VOMIT, PASSION, and SEX. The low-arousal stimulus words were WHITE, POND, BERRY, FLOWER, WALK, PENCIL, GLASS, AND CARROT. The response items were single digits. Three groups of Ss learned a low-arousal list; three learned a high-arousal list; and three learned a mixed list of half low- and high-arousal words. Measures of skin resistance were taken during learning. Within each list type, one group recalled the list at 2 minutes after learning, one group recalled at 45 minutes, and one group recalled at one week. Walker and Tarte found that the capacity to recall the number associated with low arousal words dropped as a function of time. The capacity to recall numbers associated with high arousal items dropped at 45 minutes and then rose slightly at one week. Although the magnitude of the effect was less than in the Kleinsmith and Kaplan studies, the results were statistically significant. Farley (1968) has recently used the stimulus words of the Walker and Tarte (1963) study in a free learning (FL) experiment. He obtained results similar to those of Walker and Tarte (1963) and Kleinsmith and Kaplan (1963, 1964) with respect to the long-term recall measure; however, he did not obtain the crossover effect between immediate and long-term recall.

Berlyne (1967) has pointed out that, although the Michigan studies have demonstrated that items learned under low arousal show high initial recall and low subsequent recall while items learned under high arousal show low initial recall and high subsequent recall relative to the low arousal items, the question has not been answered whether the facilitation or inhibition is a performance or a learning effect. He has argued that one is justified in stating that Condition X has affected learning if Ss trained with X and Ss trained without X behave differently in a test session conducted a day or more later when both groups are treated alike. On the other hand, if Ss trained alike on the first day behave differently when subjected to different test conditions on the second day, one can conclude that the experimental conditions have affected performance. In the case of the Michigan studies, intervals of at least one day intervened between the training and testing, but the stimulus items which were presumably responsible for arousal effects were again presented to the Ss on the test day.

There are a few experiments with designs that permit learning and performance effects to be separated. These studies have usually attempted to manipulate arousal in such a way so as to preclude the confounding of the effects of general arousal level and the effects of the arousal elicited by particular words which are part of the learning task itself. Alper (1948) attempted to induce arousal by giving "ego-oriented" instructions (informing the Ss that the task was a measure of intelligence) on a PA list to one half of her Ss. The remaining half of the Ss were given standard "task-oriented" instructions. She tested for recall immediately after learning and one day later. "Ego-oriented" Ss not only recalled significantly more new items on Day 2 than on Day 1 but also recalled on Day 2 significantly more of the same items they had recalled on Day 1 than did the "task-oriented" Ss.

In a recent study employing drugs, Batten (1967) induced arousal by giving each of his Ss dexedrine or phenobarbital prior to PA learning, by manipulating instructions to half the Ss so as to increase uncertainty and to promote "ego-involvement" (telling the Ss that the task was a measure of intelligence and that the Es were going to find out how the Ss really operated) and by administering the Stroop Color-Word Test (Jensen & Rohwer, 1966). The PA stimuli were words judged to be emotionally

neutral: PAPER, AMONG, FAR, UPON, SUCH, MOST, BACK, and THAN. The responses were single digits. Following a single presentation of the lists, Batten tested for recall 2 minutes, 20 minutes, 45 minutes, 1 day, and 1 week later. Results were in the direction suggested by the Michigan experiments but were not statistically significant.

King and his associates (Harper & King, 1967; King, 1963; King & Dodge, 1965; King & Walker, 1965; King & Wolf, 1965) have used a method of delayed auditory feedback to induce arousal. They have found that immediate retention of prose material practiced under delayed auditory feedback of .2 to .8 seconds is significantly poorer than that obtained from appropriate controls. However, on a long-term (24-hour) retention test, material practiced under delayed auditory feedback yielded greater retention, relative to the initial amount of material recalled, in comparison to the control group. In other words, the delayed auditory feedback group showed greater resistance to forgetting over the 24-hour period.

Berlyne, Borsa, Craw, Gelman, and Mandell (1965) and Berlyne, Borsa, Hamacher, and Koenig (1966) have induced arousal by using white auditory noise. The assumption that white noise is arousing is supported by the evidence that white noise activates the recticular arousal system (Berrien, 1946; Costello & Hall, 1967; Gibson & Hall, 1966) and the finding that continuous white noise causes skin resistance to drop significantly over a period of 15-20 minutes under conditions that would otherwise leave skin resistance virtually unchanged (Berlyne & Lewis, 1963).

Berlyne et al. (1965), in the first of a series of PA experiments with white noise as the agent of arousal, used dysyllabic male first names as response terms and visual patterns as stimulus terms. They found that recall was impaired when Ss were administered 72 decibels (dbs.) of white noise during the two training trials and during the test trial 24 hours later. They suspected, however, that the results were in part due to the characteristics of the visual patterns used as stimuli.

In a second experiment, Berlyne et al. (1965) used single dysyllabic adjectives (e.g., glassy), heterogeneous dysyllabic adjectives (e.g., glassy crucial), and homogeneous dysyllabic adjectives (e.g., crucial crucial) as stimuli. The response terms were dysyllabic male first names. One-quarter of the items were learned under white noise and tested the next day under white noise; one-quarter were learned with white noise and tested without white noise; one-quarter were learned without white noise and tested under white noise; and one-quarter were learned and tested without white noise. Five groups of Ss received different intensities of white noise ranging from 35 dbs. to 75 dbs. They found that on the training day there was significantly less recall for items learned under white noise as compared to items learned with no white noise. On the test day 24 hours later, items learned under white noise the day before were recalled significantly more often than non-white-noise items. No significant effect due to white noise during the test trial appeared. Variations in white noise intensity had no effect. On the basis of these two experiments, they conclude that white-noise-induced arousal has a facilitative effect on learning rather than performance.

In a third PA experiment, Berlyne, Borsa, Hamacher, and Koenig (1966) again used single dysyllabic adjectives as stimulus terms and single dysyllabic male first names as response terms. Noise conditions were varied so that noise appeared only during the presentation of the stimulus, during the interval between items, during the presentation of the stimulus and response, or not at all. They found that white noise during presentation of stimulus and response terms in training trials significantly increased recall in a test trial given 24 hours later. Whether white noise was present or absent after the response made no significant difference on the 24-hour measure of retention. They also found that during training on Day 1, white noise under all presentation conditions had no detrimental effect on recall. This finding is contrary to the previous findings of Berlyne et al. (1965) and Kleinsmith and Kaplan (1963, 1964) in which arousal had a detrimental effect on immediate recall but enhanced long-term recall relative to the nonarousal condition.

Thus, the bulk of the foregoing studies employing arousal-producing stimulus terms, delayed auditory feedback, drugs, frustrating tasks, and white noise suggest that arousal facilitates long-term recall. One inconsistent finding of the cited studies has concerned the relationship of arousal and immediate recall. The Michigan group (Kleinsmith & Kaplan, 1963, 1964; Walker & Tarte, 1963), Berlyne et al. (1965), King & Dodge (1965), and King & Wolf (1965) found arousal to have a detrimental effect on immediate recall. On the other hand, Alper (1948), Berlyne et al. (1966) and Farley (1968) found arousal to have no significant inhibiting effect on immediate recall but to increase long-term recall relative to non-arousal conditions. Berlyne et al. (1966) in discussing their results have suggested that the effects of arousal may be dependent on the nature of the learning material used.

One of the objectives of the present research was to adapt part of the Berlyne et al. (1966) experimental paradigm to investigate the effects of arousal induced by white noise on learning and long-term recall following the three major verbal learning procedures: paired-associate learning, serial learning, and free learning (Mandler, 1967). After reviewing the literature involved in these three types of learning, Mandler (1967) has suggested that they are not simply different methods for studying the same learning processes but that each involves unique properties.

Jensen (1962) and Jensen and Rohwer (1965) found no significant overall transfer from serial to PA learning. This again suggests that PA and SL involve two distinct processes. No studies are available which have tested for transfer between FL and either SL or PA learning. Moreover, no published research is available on the influences of arousal induced by white noise on learning and recall in the FL paradigm. Additionally, no research has been reported by American investigators on the influence of white-noise-produced arousal in SL, although Berlyne (1967) refers to a tangentially relevant German study which demonstrated facilitation of immediate recall in SL through arousal-induction by white noise. However, this study did not include a long-term recall measure. Where PA learning is concerned, the present research extended the previous work of Berlyne et al. (1966) by employing consonant-vowel-consonant (CVC) nonsense-syllable pairs of known associative characteristics. This material was employed in order to exercise greater control over associative and mediational factors than was possible with Berlyne's lists, which were familiar male dysyllabic names and dysyllabic adjectives of unspecified associative properties. These CVC's were also utilized in the SL and FL experiments.

II
EXPERIMENT ONE

The first experiment concerned the effects of arousal as induced by white noise on the learning and recall of paired-associate CVC nonsense syllables. In an effort to extend the Berlyne et al. (1966) experimental paradigm to the use of nonsense syllables, their essential experimental procedure was employed. The specific hypothesis to be tested was that arousal would facilitate long-term recall of the response terms.

METHOD

Subjects

The subjects were 20 volunteers from an undergraduate learning course in educational psychology at the University of Wisconsin; there were 4 males and 16 females. Each S received points for his participation; these points contributed to his letter grade for the course. Volunteers who reported hearing difficulties were not used.

Materials and Equipment

A list of ten PA's were constructed in which both stimulus and response terms were CVC nonsense syllables with a Glaze (1928) association value of 87–93%. All of the syllables were pronounceable. The lists were constructed according to the rules suggested by Hilgard (1951). The ten PA's were as follows: HOB–FES; MID–GOV; DEK–WIM; RUF–SAB; VIN–TOK; LAZ-REG; KET–BIR; SUG-VAC; JAS–DUL; COR–LUN.

A Grason-Stadler Model 901 B white noise generator and a Telephonics TDH-39 binaural headset were used to deliver 75 dbs. of white noise individually to each S. Approximately 55 dbs. of ambient noise was present in the experimental room at the time of testing. The reference level for these measurements was .0002 dynes/cm.[2] The choice of 75 dbs. of white noise was based on the use of this level by Berlyne et al. (1966).

The Ss GSR was measured using a Gilson Model M5P Polygraph and dual finger cup electrodes. Burdick Electrocardiograph electrode jelly was used with the cup electrodes. The skin was prepared using alcohol.

The time intervals for the presentation of the learning material were controlled by programmed tones delivered monaurally via an earphone to the E through the use of a Cousino Syncro-Repeater Model SR-7341.

Procedure

Each of the Ss was randomly assigned to a white noise (WN) or no white noise (NWN) condition during the initial learning of the list on Day 1. Thus, each condition contained ten Ss. Each S was brought back 24 hours later (Day 2) for a single test trial. No white noise was presented during the 24-hour test trials.

The Ss were run individually. Each S underwent three training trials in immediate succession on Day 1. During these trials, the S wore the headset whether or not he was in the WN condition. The S's GSR was measured throughout the training and test trials; the electrodes were attached to the first and second digits of the right hand. However, due to technical difficulties in the interpretation of this measure, analyses of these data are not presented here. The Ss in the WN condition were told that they could expect to hear noise over the headset. Noise was presented throughout the training trials following the reading of the instructions.

The PA's were presented on flash cards in three random orders. During the training trials, each stimulus term appeared alone for 4 seconds and then appeared for an additional 2 seconds with the response term

to the right of it. Following this, there was an interval of 6 seconds with a blank card appearing, after which the next stimulus term came into view. The S was instructed to anticipate the response term whenever possible during the period when the stimulus term was alone, but the response term had to be pronounced as soon as it appeared whether or not it had been anticipated. On the 24-hour test trial, stimuli were presented for 4 seconds with intervals of 4 seconds. The S was instructed to pronounce the corresponding response term if possible.

On Day 1, the number of response items correctly anticipated on Trials 2 and 3 was recorded. The S could not, of course, anticipate any of the responses on Trial 1. The number of response items correctly anticipated on the test trial on Day 2 was also recorded.

RESULTS

Table 1 presents the mean number of correct responses on the two training trials and the 24-hour test trial for each condition.

Table 1

Mean Number of Correct Responses on Training and Test Trials

Condition	Training Trial 2	Training Trial 3	Test Trial
WN	1.0	2.3	2.1
NWN	1.7	3.1	3.6

In order to determine the effects of noise-induced arousal on immediate recall a two-way repeated measures analysis of variance (Winer, 1962) was performed on the data from training Trials 2 and 3. The results of this analysis are summarized in Table 2.

The results of the analysis reported in Table 2 indicate that the number of correct anticipations on training Trial 3 was significantly greater ($p < .01$) than the corresponding number on training Trial 2. There were, however, no significant main effects and no significant interactions due to the white noise condition.

The first analysis indicated that there were no significant differences between the two conditions; thus, the number of correct responses on training Trial 3 was used as a measure of immediate recall. In order to test for the effect of white noise on the 24-hour retention measure, a further two-way repeated measures analysis of variance was performed on the number of correct responses on training Trial 3 and the number of correct responses on the 24-hour test trial. The results of this analysis are summarized in Table 3.

Table 2

Summary of Analysis of Variance on Training Trials and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	5.63	2.00
Subjects within Conditions	18	2.82	
Trials	1	18.23	20.25**
Condition x Trials	1	.02	<1
Trials x Subjects within Conditions	18	.90	
Total	39		

** $p < .01$

Table 3

Summary of Analysis of Variance on Immediate and Long Term Recall and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	13.22	2.18
Subjects within Conditions	18	6.07	
Trials	1	.22	<1
Condition x Trials	1	1.23	<1
Trials x Subjects within Conditions	18	1.39	
Total	39		

From this analysis, it can be concluded that there was no significant effect due to trials or conditions, and there were no significant interactions. This long-term retention trend is depicted in Figure 1 in which the data from the last trial on Day 1 and the 24-hour retention trial are plotted.

DISCUSSION

The prediction that white-noise-induced arousal would facilitate the long-term recall

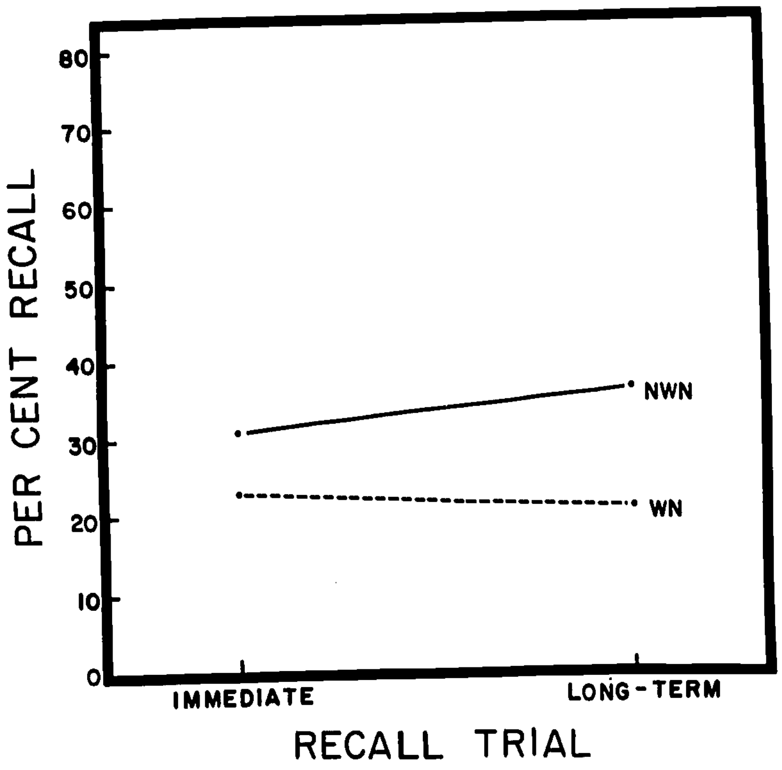

Fig. 1. Immediate and long-term recall under white noise (WN) and no white noise (NWN) conditions in paired-associate learning.

of CVC PA's did not receive confirmation in this experiment. The only result consistent with the Berlyne et al. (1966) experiment was that white noise did not significantly affect the recall scores on the training trials (Day 1). There was a tendency for the WN group's performance to be depressed relative to the performance of the NWN group. Although the differences are not significant, the NWN group's recall scores on the test trial were slightly better than their recall scores on the training trials. This suggests a slight reminiscence effect. However, the recall scores of the WN group on the test trial are only slightly reduced from their recall scores on the training trials. In both conditions it is clear that there was marked resistance to forgetting over 24 hours.

The failure to find a significant difference in either condition on recall trials 24 hours apart and the generally low recall scores of both conditions suggest that the task may have been too difficult to test effectively the Berlyne et al. (1966) findings. It might be suggested that a "floor effect" was obtained in which the Ss did not show an adequate amount of learning to effectively test the hypothesis under consideration (Runquist, 1966). Three quickly paced training trials on a list of CVC nonsense syllables may have been insufficient to insure learning of an adequate number of the new associations. Using Underwood and Schulz's (1960) two-stage analysis of PA learning, it may be hypothesized that the Ss had insufficient time to accomplish both "response-learning" and "associative-hook-up."

Runquist (1966) has suggested that the use of CVC PA's as both stimuli and responses may promote interference. This factor may have been operating in the present paradigm. A more sensitive test of the effects of white-noise-induced arousal might be made by using CVC syllables as stimulus terms and numbers as response terms in the PA list. However, regardless of the problems delineated above, it must be concluded that with the CVC PA's of known and controlled associative properties, no significant effect on learning and retention could be attributed to arousal.

III

EXPERIMENT TWO

The second experiment was designed to explore the effects of white-noise-induced arousal on the serial learning of CVC nonsense syllables. It was hypothesized that, if the effects of arousal are general as Berlyne (1967) indicates, arousal should facilitate long-term recall of items in the SL list.

METHOD

Subjects

The subjects were 20 volunteers from an undergraduate learning course in educational psychology at the University of Wisconsin; there were 8 males and 12 females. Experimental participation requirements were identical to those in Experiment One.

Materials and Equipment

A ten-item SL list was constructed using the stimulus terms of the PA list of Experiment One. The CVC syllables were as follows: KET–HOB–MID–DEK–RUF–COR–SUG–JAS–VIN–LAZ. The white noise generator, headset, room conditions, polygraph, timing device, and noise intensity were the same as in Experiment One.

Procedure

Each of the Ss was randomly assigned to a white noise (WN) or no white noise (NWN) condition during the initial learning of the list on Day 1. Thus, each condition contained ten Ss. Each S was brought back 24 hours later (Day 2) for a single test trial. No white noise was presented during the 24-hour test trials.

The Ss were run individually. Each S underwent three training trials in immediate succession on Day 1. During these trials, the S wore the headset whether or not he was in the WN condition. The S's GSR was measured throughout the training and test trials; the electrodes were attached to the first and second digits of the right hand. However, due to technical difficulties in the interpretation of this measure, analyses of these data are not presented here. The Ss in the WN condition were told that they could expect to hear noise over the headset. Noise was presented throughout the training trials following the reading of the instructions.

The SL list was presented by means of flash cards. The list was preceded by a card on which three asterisks appeared. On the training trials, the items were presented at a 3-second rate with a 6-second inter-trial interval. The choice of these intervals was based on common practice as summarized by Kausler (1966). The Ss were instructed to anticipate the first item in the list when they saw the card with the three asterisks and to continue anticipating the next item in the list. The next serial item had to be pronounced as soon as it appeared whether or not it had been correctly anticipated. On the 24-hour test trial, the items in the list were presented for 3 seconds. The S was instructed to anticipate the next item in the list if possible.

On Day 1, the number of serial items correctly anticipated on Trials 2 and 3 was recorded. The S could not anticipate any of the items on training Trial 1 because it was his first time through the list. The number of items correctly anticipated on the test trials on Day 2 was also recorded.

RESULTS

Table 4 presents the mean number of correct responses on the two training trials and the 24-hour test trial for each condition.

In order to determine the effects of noise-induced arousal on immediate recall a repeated measures analysis of variance was performed on the data from training Trials 2 and 3. The results of this analysis are summarized in Table 5.

Table 4

Mean Number of Correct Responses on Training and Test Trials

Condition	Training Trial 2	Training Trial 3	Test Trial
WN	2.6	4.4	2.8
NWN	2.9	4.8	3.3

Table 5

Summary of Analysis of Variance on Training Trials and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	1.23	<1
Subjects within Conditions	18	2.45	
Trials	1	34.23	35.66**
Condition x Trials	1	.02	<1
Trials by Subjects within Conditions	18	.96	
Total	39		

** $p < .01$

The results of the analysis reported in Table 5 indicate that the number of correct anticipations on training Trial 3 was significantly greater ($p < .01$) than the corresponding number of correct anticipations on training Trial 2. There was, however, no significant main effect and no significant interaction due to the white noise condition.

The first analysis indicated that there were no significant differences between the two conditions; thus, the number of correct responses on training Trial 3 was used as a measure of immediate recall. In order to test for the effect of white noise on the 24-hour retention measure, a repeated measures analysis of variance was performed on the number of correct responses on training Trial 3 and the number of correct responses on the 24-hour test trial. The results of this analysis are summarized in Table 6.

The analysis indicated that the number of correct anticipations on the test trial was significantly less ($p < .05$) than the corresponding number of correct anticipations on training Trial 3. However, there was no significant interaction effect and no effect due to white noise

Table 6

Summary of Analysis of Variance on Immediate and Long-Term Recall and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	2.02	<1
Subjects within Conditions	18	3.90	
Trials	1	24.02	5.73*
Condition x Trials	1	.03	<1
Trials x Subjects within Conditions	18	4.19	
Total	39		

* $p < .05$

condition. The long-term retention trend is depicted in Figure 2 in which the data from the last trial on Day 1 and 24-hour retention trial are plotted.

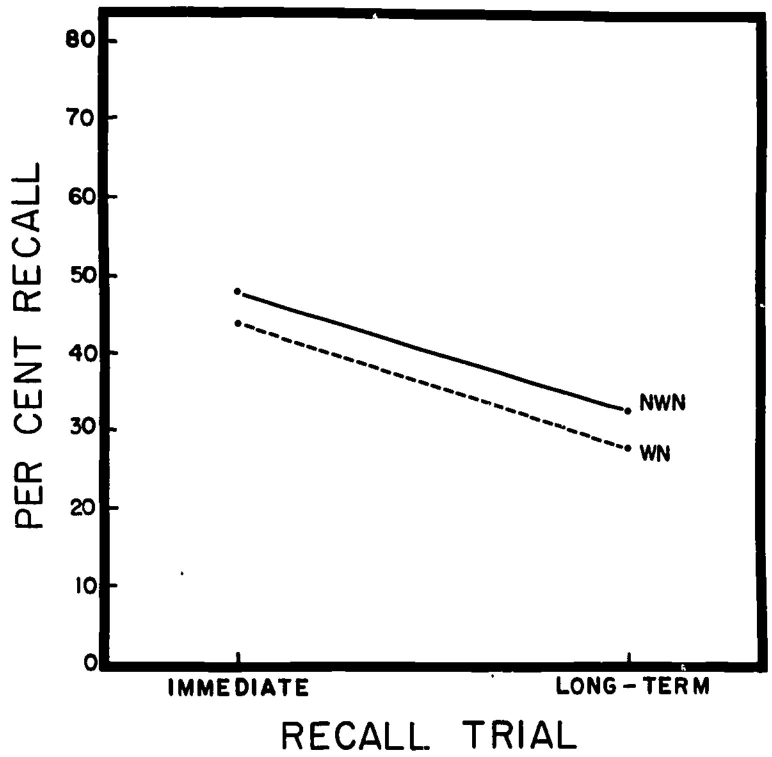

Fig. 2. Immediate and long-term recall under white noise (WN) and no white noise (NWN) conditions in serial learning.

DISCUSSION

The prediction that white-noise-induced arousal would facilitate the long-term recall of items in the SL list was not confirmed in this experiment. White noise had no significant

effect on either immediate or long-term recall of SL items. The only significant effects were that the number of correct responses significantly increased on the training trials and that the number of correct responses on the test trial was significantly less than on the training trials for both conditions. Thus, a "learning" effect and a "forgetting" effect were found but no differential effect due to arousal seemed to be operating. No apparent explanation for this failure to find significant differences due to noise-induced arousal is suggested by the data.

Malmo (1959) and Duffy (1962) had hypothesized that an inverted U-shaped relationship exists between arousal and performance measures such that optimum performance is associated with intermediate levels of arousal. Berlyne (1967) has suggested that this same type of nonmonotonic relationship may exist between arousal and learning measures. In the present experiment, the level of arousal as induced by the white noise may not have been sufficiently high to differentially affect the recall of the ten item SL list of CVC nonsense syllables; conversely, the induced level of arousal may have been too low, leading to the same result. Such a hypothesis could be tested with SL learning under white noise intensities ranging from very low to much higher than the levels used in the present study.

IV
EXPERIMENT THREE

The rationale for the third experiment was much the same as that for the first two experiments. In this case, the experiment was designed to explore the effects of arousal on FL. Again, the hypothesis was that arousal would facilitate long-term recall of items in the FL list.

METHOD

Subjects

The subjects were 20 volunteers from an undergraduate learning course in educational psychology at the University of Wisconsin; there were 2 males and 18 females. Experimental participation requirements were identical to those of Experiment One.

Materials and Equipment

The ten-item FL list was identical to the SL list of Experiment Two. The white noise generator, headset, polygraph, and timing device were the same as in Experiment One. The white noise intensity was 79 dbs. Approximately 40 dbs. of ambient noise was present in the experimental room at the times of testing. The reference level for these measurements was .0002 dynes/ cm.[2]

Procedure

Each of the Ss was randomly assigned to a white noise (WN) or no white noise (NWN) condition during the initial learning of the list on Day 1. Thus, each condition contained ten Ss. Each S was brought back 24 hours later (Day 2) for a single test trial. No white noise was presented during the 24-hour test trials.

The Ss were run individually. Each S underwent three training trials in immediate succession on Day 1. During these trials, the S wore the headset whether or not he was in the WN condition. The S's GSR was measured throughout the training and test trials; the electrodes were attached to the first and second digits of the right hand. However, due to technical difficulties in the interpretation of this measure, analyses of these data are not presented here. The Ss in the WN condition were told that they could expect to hear noise over the headset. Noise was presented throughout the training trials following the reading of the instructions.

The FL list was presented to the subject in two random orders on flash cards. During the training trials, each item in the list appeared for 2 seconds. The S was instructed to pronounce the syllables as they appeared. Following a training trial, the S was instructed to recall as many of the syllables as he could. The order in which the items were recalled was not important. For the 24-hour test trial, the S was asked to recall as many as possible of the syllables that he had seen the day before.

On Day 1, the number of items correctly recalled by each S on Trials 1 and 2 was recorded. The number of items correctly recalled during the 24-hour test trial was also recorded.

RESULTS

Table 7 presents the mean number of correct responses on the two training trials and the 24-hour test trial for each condition.

In order to determine the effect of noise-induced arousal on immediate recall a repeated measure analysis of variance was performed on the data from training Trials 1 and 2. The results of this analysis are summarized in Table 8.

The results of the analysis reported in Table 8 indicate that the mean number of correct

Table 7

Mean Number of Correct Responses on Training and Test Trials

Condition	Training Trial 1	Training Trial 2	Test Trial
WN	5.6	6.8	4.8
NWN	4.7	6.9	3.5

Table 8

Summary of Analysis of Variance on Training Trials and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	1.60	<1
Subjects within Condition	18	7.57	
Trials	1	28.90	23.12**
Condition x Trials	1	2.50	2.00
Trials x Subjects within Conditions	18	1.25	
Total	39		

** $p < .01$

responses on training trial was significantly greater ($p < .01$) than the corresponding number of correct responses on training Trial 1. There were, however, no significant main effect and no significant interactions due to the white noise condition.

The first analysis indicated that there were no significant differences between the two conditions. As in the previous analyses, the number of correct responses on the last training trials was used as a measure of immediate recall and the number of correct responses on the test trial was used as a long-term recall measure. A repeated measures analysis of variance of the immediate and long-term recall data is summarized in Table 9.

The analysis in Table 9 indicated that the number of correct responses on the test trial was significantly less ($p < .01$) than the number of correct responses on the training trial. Also, there was a significant interaction ($p < .05$) due to the white noise condition. Items which were learned under the influence of white noise were recalled significantly more often than non-white-noise items. The long-

Table 9

Summary of Analysis of Variance on Immediate and Long Term Recall and High- and Low-Arousal Conditions

Source	df	MS	F
Condition	1	3.60	<1
Subjects within Conditions	18	7.63	
Trials	1	72.90	68.13**
Condition x Trials	1	4.90	4.58*
Trials x Subjects within Conditions	18	1.07	
Total	39		

* $p < .05$ ** $p < .01$

term retention trend is depicted in Figure 3 in which the data from the last trial on Day 1 and the 24-hour retention measure are plotted.

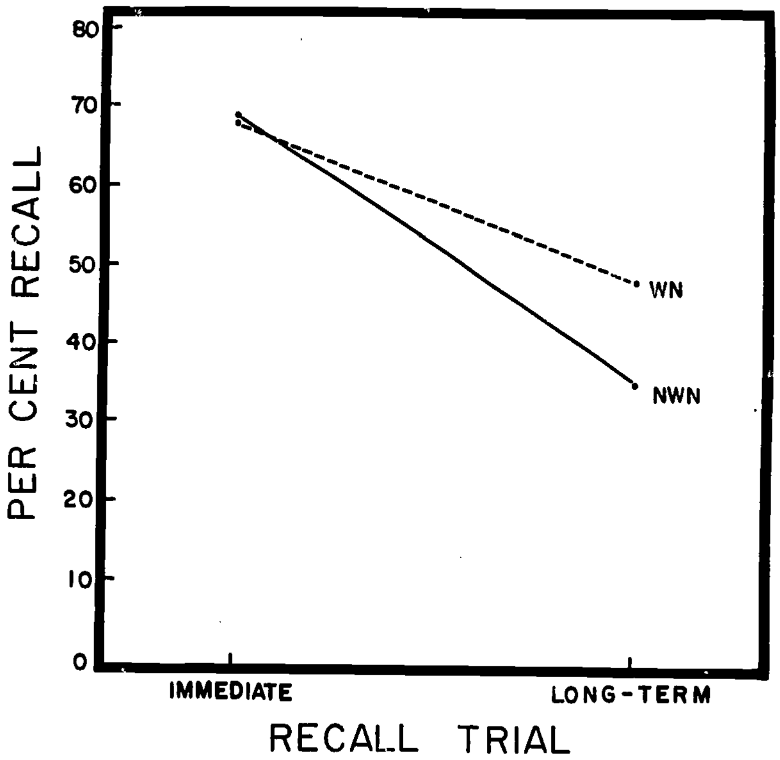

Fig. 3. Immediate and long-term recall under white noise (WN) and no white noise (NWN) conditions in free learning.

DISCUSSION

The prediction that white-noise-induced arousal would facilitate the long-term recall of items in the FL list was supported in this experiment. The Berlyne et al. (1966) finding that during training the recall of items learned

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under the influence of white noise is about the same as the recall of items learned under the influence of no white noise was confirmed. However, significantly fewer of the WN items are forgotten over a 24-hour period. Berlyne et al. (1966) obtained this differential effect in a PA learning paradigm; in this experiment the differential effect occurred in a FL paradigm. The fact that a delay of one day occurred between the training and test trials would seem to indicate that in the FL situation, arousal has a marked effect on learning rather than performance. The significance of finding a facilitative effect due to arousal on long-term recall in the FL task but no such effect in the PA and SL tasks will be discussed in the following section.

V
GENERAL DISCUSSION

The results of the first two of these experiments failed in their purpose of extending Berlyne's findings to the paired-associate and serial learning of CVC nonsense syllables. White-noise-induced arousal had no significant effect on the long-term recall of items in the SL or PA list. However, white-noise-induced arousal had a significantly facilitative effect on long-term recall in the FL paradigm. The finding that arousal did not have a detrimental effect on immediate recall (Berlyne et al., 1966) was substantiated in all three verbal learning paradigms in the present research.

If the three learning tasks in this experiment are placed on a continuum ranging from most structured to least structured, it would seem that the order of the tasks might be PA, SL, and FL. In the PA task, the S supposedly had to learn ten responses and ten associations. This was a difficult task given the constraints of three learning trials. Consequently, as indicated by the low recall scores, little learning and little forgetting occurred. In the SL task, the S had to learn ten items and their serial order. This would seem to be an easier task than that of PA learning, and the recall scores were higher. There was also a significant decrement in recall from training to test trials in the SL paradigm. However, there were no significant differences between the two arousal conditions. A differential effect due to arousal was found only in the task which in terms of imposed structure would seem to have been easiest for the S—the FL situation. These results seem to suggest that as the task becomes easier for the S it also becomes more sensitive to the differential effects of arousal. This supports in a general fashion the Berlyne et al. (1965) contention that the effects of arousal are dependent on the nature of the material to be processed.

Although it is realized that the ordering of the learning tasks along a difficulty dimension as suggested above is subjective, one might argue that such a procedure has heuristic value in light of theory relating task complexity to motivation and/or arousal. Yerkes and Dodson (1908) advanced a hypothesis which held that the effects of motivation on learning depended on the nature of the learning task. High levels of motivation optimally facilitated the learning of simple tasks and lower levels of motivation optimally facilitated the learning of more complex tasks. Speculating that the PA, SL, and FL paradigms as used in the present study represent decreasing levels of difficulty, one might hypothesize that the level of arousal employed was at a value high enough to facilitate learning in the simpler FL paradigm. On the other hand, the arousal level interfered with learning in the more difficult PA paradigm; the SL task fell between these two extremes. It will be recalled that white noise had a somewhat debilitating effect on PA learning and recall; however, this did not achieve statistical significance. A test of the foregoing notions would include PA, SL, and FL under a wide range of noise conditions (arousal levels). However, given the lack of significance in the PA analysis, the significant effect only on long-term recall in the FL analysis, and the problem of task-difficulty analyses with these learning paradigms, one would not wish to place much weight on such an interpretation.

Another possible interpretation of the significant effect of white noise on long-term recall in the FL paradigm may have to do with the possible characteristics of the stimulus in FL as well as the importance of retrieval cues in this procedure. The stimulus is relatively clear in the PA task and also somewhat explicable in the SL task, but very little understood in the FL situation (Mandler, 1967). It might be hypothesized that in FL the stimulus could represent the total learning situation (room, etc.) and that in the present research the presence

of white noise made the learning situation more discriminable and differentiated from other "situations." This enhanced the total learning situation as a cue for retrieval of the FL list. The no-white-noise condition would render the learning situation less differentiated than the white noise condition and make it less effective as a cue for the FL list when the S was tested in the same situation one day later. The PA and SL situations would be expected to show less effect of white noise as it may be suggested that the stimulus is more a part of the list itself. Such a hypothesis could be tested by varying the place of learning and of long-term recall, employing the three learning paradigms and white noise and no white noise conditions.

Berlyne (1967) feels that the favorable long-term effect of arousal on recall would seem to indicate that arousal has a reinforcing effect (in a broad sense of the term) on verbal learning. To Berlyne (1967) "reinforcement" is used to denote a factor that promotes learning by strengthening a response. In this sense, reinforcement is any factor other than the elements to be learned that contributes to associative strength. Reinforcing events are often difficult to demonstrate in a verbal learning situation; however, they must be operating as contiguity alone is often not sufficient to insure verbal learning. The reinforcing effects of arousal can be demonstrated only when there is sufficient delay between training and testing for the transient cue effects and transient motivational conditions to dissipate. Using the distinction between performance and learning (Berlyne, 1967) and the finding that white-noise-induced arousal during the long-term recall trials has no effect on recall (Berlyne et al., 1965), it would seem that the transient effects of arousal may inhibit immediate recall. This would be a performance effect. On the other hand, when the long-term consequence of arousal is to facilitate retention, a learning effect is obtained.

The reinforcement position of Berlyne (1967) is invoked as a possible alternative to the "action-decrement" theory of Walker (Walker & Tarte, 1963) as an explanation for the empirical finding that arousal facilitates long-term recall but does not necessarily inhibit immediate recall. The "action-decrement" theory would necessarily predict a detrimental effect of arousal on immediate recall. This finding was not confirmed in the present experiment. However, it is probable that the phenomenon of high-arousal learning resulting in better long-term recall is somehow based on consolidation of the memory trace. The exact mechanism of this consolidation is not presently known.

The finding that arousal facilitated long-term retention in free learning has several implications for education, keeping in mind, however, that such results would require replication in additional studies. First of all, Levonian (1967) using continuously presented information (a driver education film) found that information presented under high autonomic arousal enhanced long-term recall. In view of the previously mentioned findings regarding the wide range of arousal-eliciting agents (arousal-producing stimuli, drugs, instructions, and white noise) and the fact that in Levonian's study joy-induced arousal had similar effects on retention, it would seem that the effect of arousal on retention is independent of the source of that arousal. This would theoretically imply that in a learning situation, the agent of arousal does not necessarily need to be inherent in the learning task. The teacher could manipulate arousal perhaps by a relatively simple agent such as white noise, although, of course, this would be much more readily employed in an individualized CAI situation. Moreover, monitoring of the student's physiological responses in a computerized teaching machine situation would facilitate the manipulation of arousal by providing information regarding the time and intensity of arousal inducement. In this way, the manipulations to aid retention would be based on knowledge of the Ss ongoing arousal state.

Secondly, Levonian (1967) has suggested that, if a classroom teacher wishes to enhance long-term retention, he should present the critical information (information to be remembered) at about the same time as some arousal-inducing agent. Lastly, studies in arousal suggest that long-term recall scores may differ from those of immediate recall as a function of arousal level during learning. In laboratory studies, interest is usually centered on relatively short-term, single-session learning data; however, in education, long-term retention should be of much greater concern. If teachers wish to evaluate learning unaffected by transient motivational conditions, it is well to insure the utilization of long-term retention measures. Of course, most achievement testing is designed to meet this criterion.

It may be concluded that establishing a relationship between arousal, learning, and retention is of considerable importance for education. The present research has suggested at least two areas that seem to be important in this relationship. The first concerns the intensity of arousal. The second involves the nature of the material to be processed in terms of task structure and difficulty. A

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